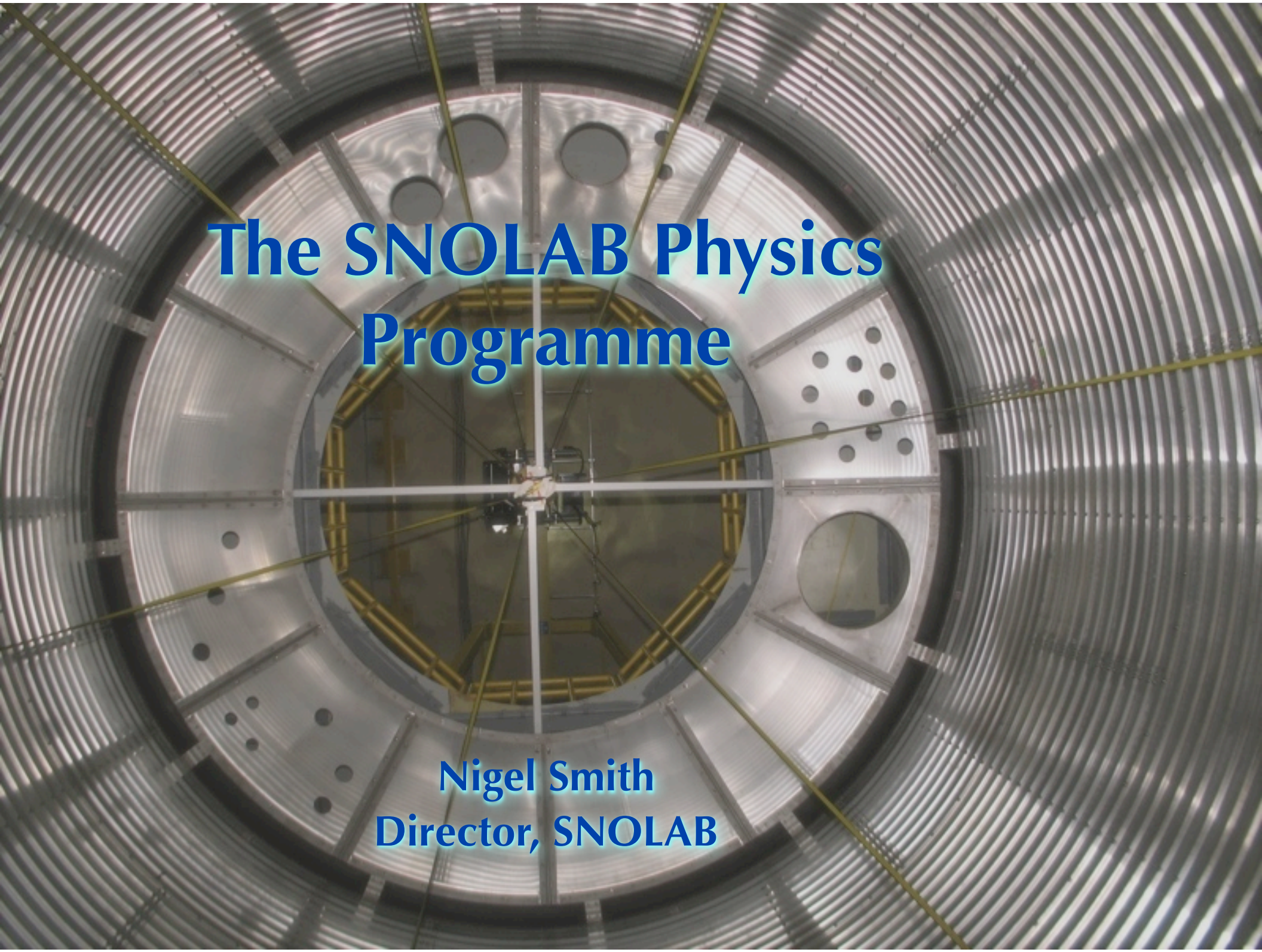


The SNOLAB Physics Programme

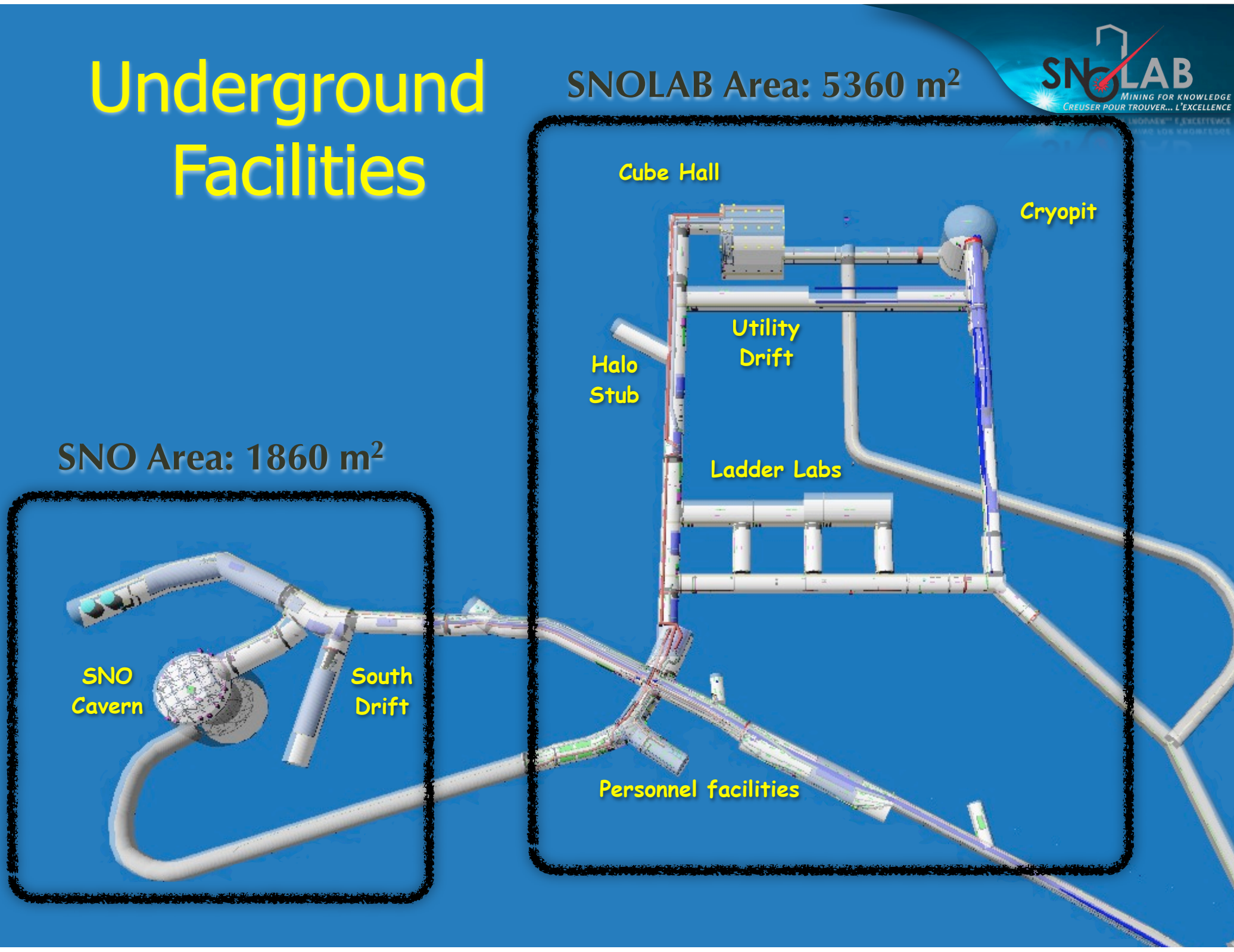
Nigel Smith
Director, SNOLAB

SNOLAB Objectives

- To promote an International programme of Astroparticle Physics
- To provide a deep experimental laboratory to shield sensitive experiments from penetrating Cosmic Rays (2070m depth)
- To provide a clean laboratory
  - Entire lab at class 2000, or better, to mitigate against background contamination of experiments.
- To provide infrastructure for, and support to, the experiments
- Focus on dark matter, double beta decay, solar & SN neutrino experiments requiring depth and cleanliness.
  - Also provide space for prototyping of future experiments.
- Large scale expt's (ktonne)
- Goal has been to progressively create a significant amount of space for an active programme as early as possible.

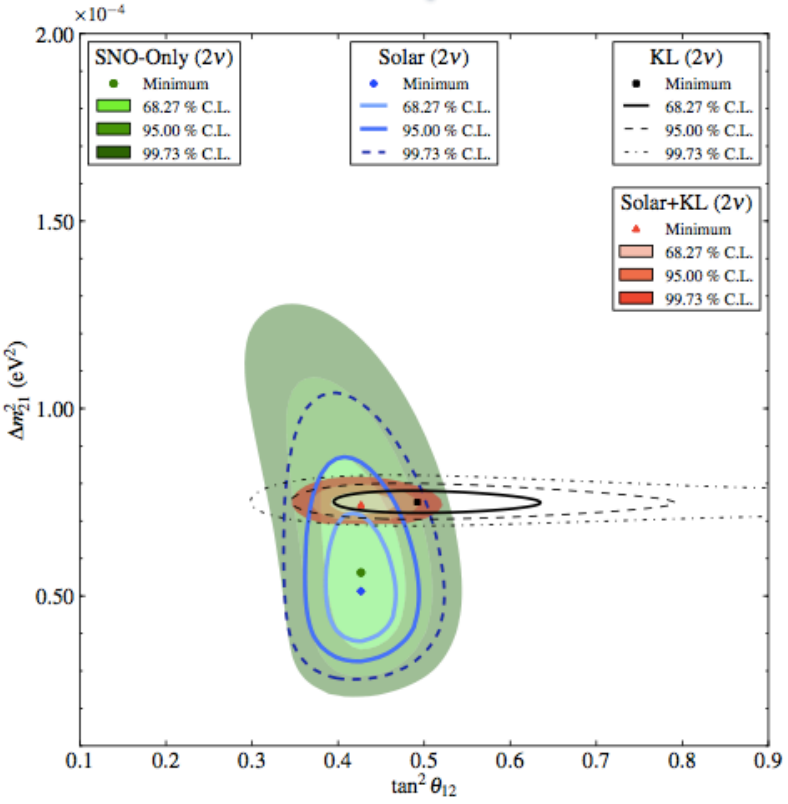
Surface Facilities

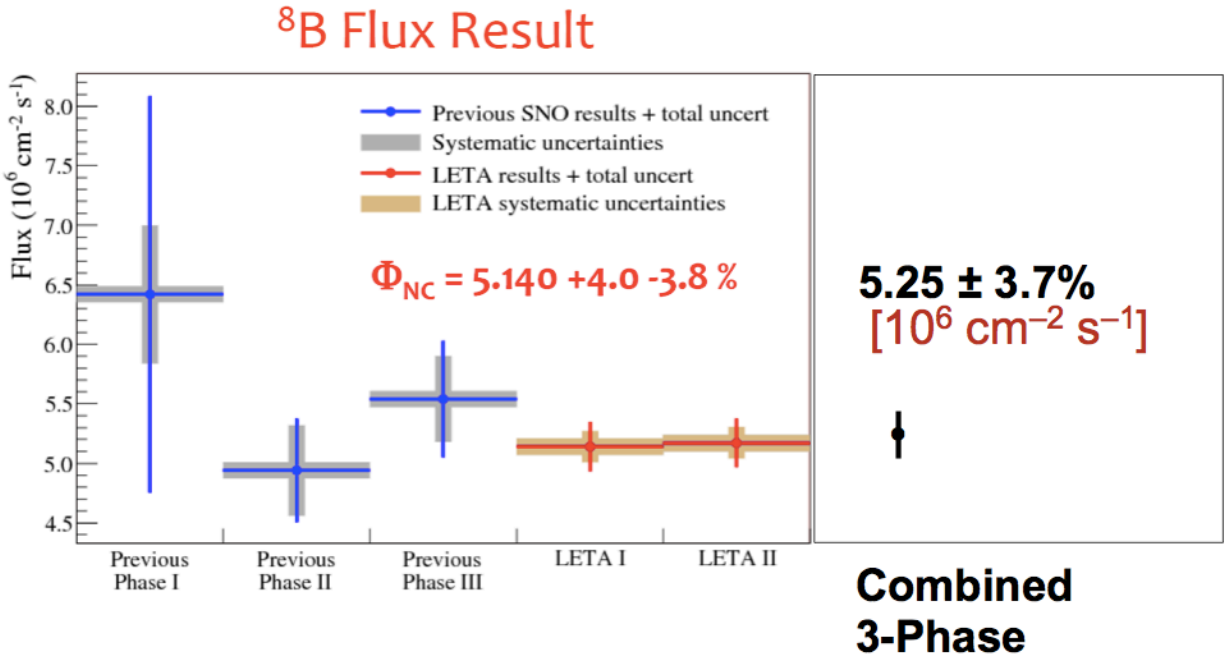
Underground Facilities



Final SNO Results

- Detected ν_x ES, ν_e CC and ν_x NC interactions in heavy water
- NC neutrons detected three ways: D, Cl, NCD
- Final combined analysis of all three phases - arXiv:1109.0763
  - includes pulse shape particle ID in NCD (alpha / n rejection)
  - improved ^{8}B and ν_e survival probability (by 20%)





Current programme: 0νββ at SNOLAB

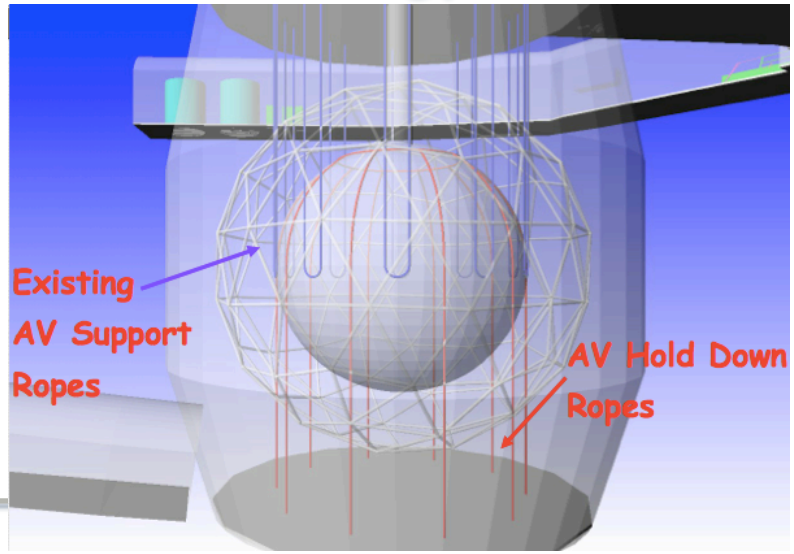
- SNO+ : $^{150}Nd \rightarrow {}^{150}Sm + e^- + e^-$
  - Uses existing SNO detector. Heavy water replaced by scintillator loaded with ^{150}Nd. Modest resolution compensated by high statistical accuracy.
  - Requires engineering for acrylic vessel hold down and purification plant. Technologies already developed.
    - SNO Cavity: repairs to cavity liner and modification of detector support to hold down the Acrylic Vessel for liquid scintillator.
    - SNO Utility Room: Development of liquid scintillator purification system.
  - Capital funding turn on fall 2010.
- EXO-gas : $^{136}Xe \rightarrow {}^{136}Ba^{++} + e^- + e^-$
  - Ultimate detector aim = large volume Xe Gas TPC
  - Developing technique to tag Ba daughter. Electron tracking capability.
  - Development work completed at SNOLAB surface facility

Current programme: Natural neutrino sources

- SNO+ :
  - Will also measure
    - solar neutrino pep line (low E-threshold)
    - geo-neutrinos (study of fission processes in crust/mantle)
    - supernovae bursts (as part of SNEWS)
    - reactor neutrinos (integrated flux from Canadian reactors)
- HALO: Dedicated Supernova watch experiment
  - Charged/neutral current interactions in lead
  - Re-use of detectors (NCDs) and material (Pb) from other systems
  - DAQ refurbishment complete, NCD installation complete, partial ops underway, full ops by end 2011
  - Will form part of SNEWS array

SNO+ Developments

- Clean and lap AV interior
  - Cleaning completed; lapping process designed
- Hold-down rope net procured, now at site
  - Anchor points installed, new liner sprayed
- Scintillator process plant
  - Design completed; large vessels procured;EH&S (fire) under review
  - Scintillator to be bought at appropriate time (for 2013)
- Upgrade electronics for high rate, lower energy
  - Completed
- Aim for water-fill tests mid-2012
  - Scintillator fill early 2013



SNO+ Developments

Protection umbrella constructed underneath SNO+ AV and PSUP for floor repair and anchor point installation

Process system design advanced, inc. EH&S
Cavity work completed - construction of 'umbrella', hold-down ropes, anchor points, AV cleaning completed, lapping underway, ..

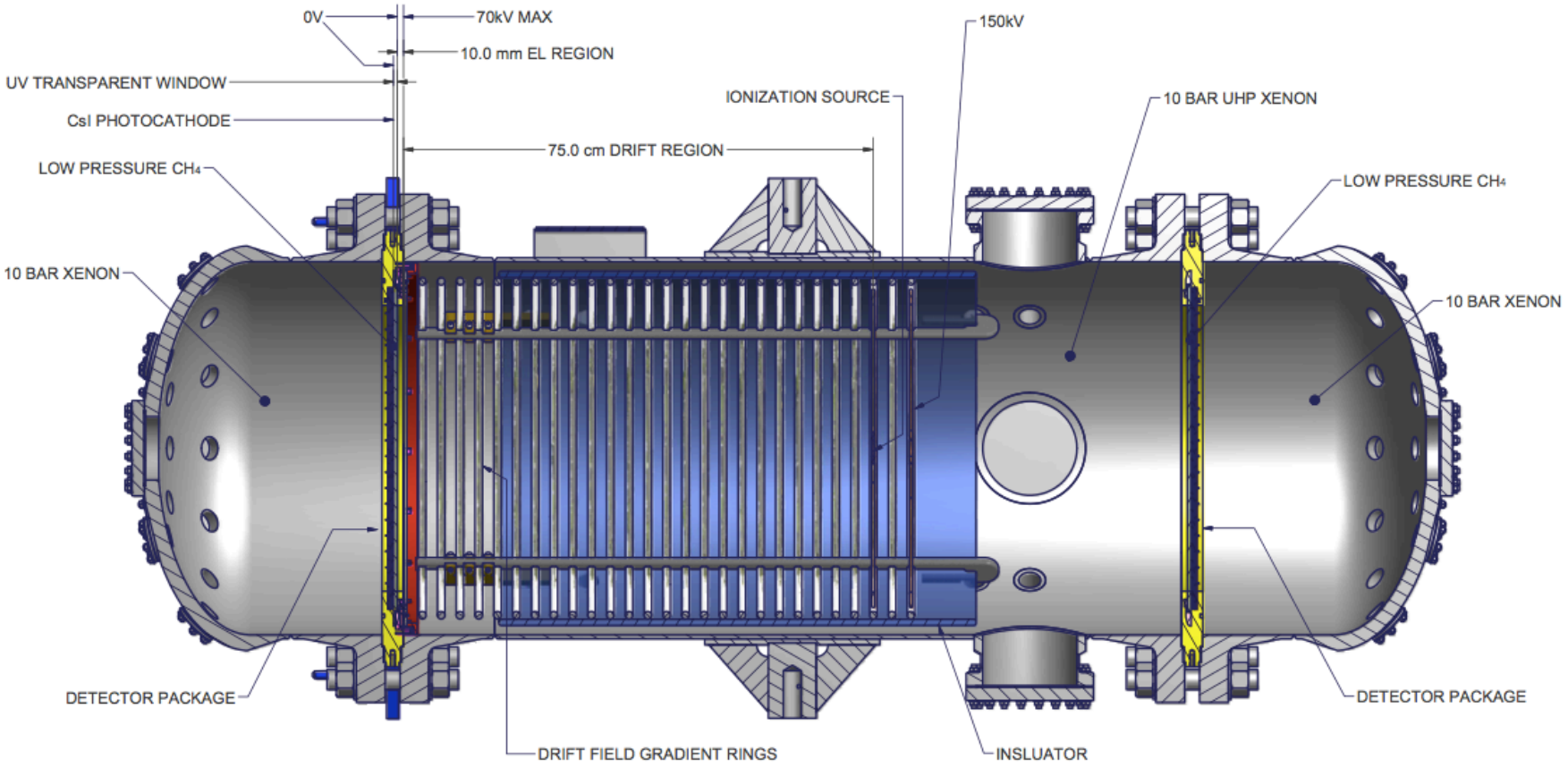
Excavating a larger space in the SNO+ Utility room to accommodate the liquid scintillator process systems.

SNO+ Developments

Completion of anchor point installation, maintaining clean room, and floor liner respray

EXO-Gas

- ^{136}Ba laser-tagging tests completed at SNOLAB
- Development of electroluminescence test chamber underway at Carleton before deployment to SNOLAB
  - Extract Ba ion from high pressure region into laser fluorescence region



HALO

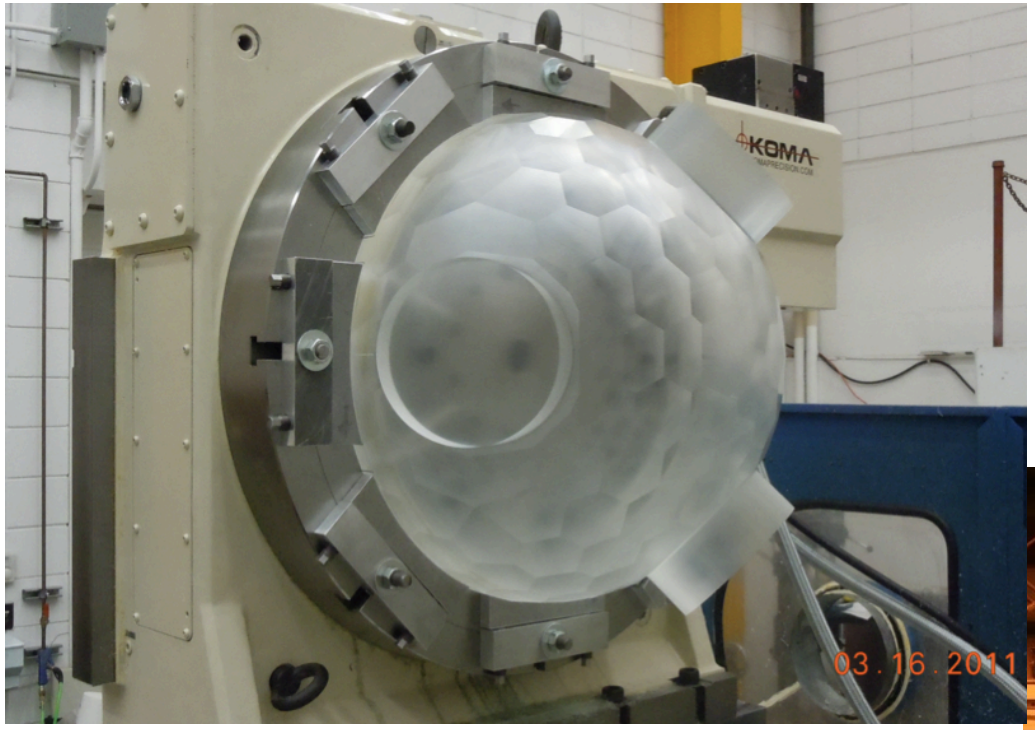

Target lead stack
NCD Inserts
NCD DAQ (refurb.d)
NCD Racks
Water/Poly shielding box

Current programme: Dark Matter at SNOLAB

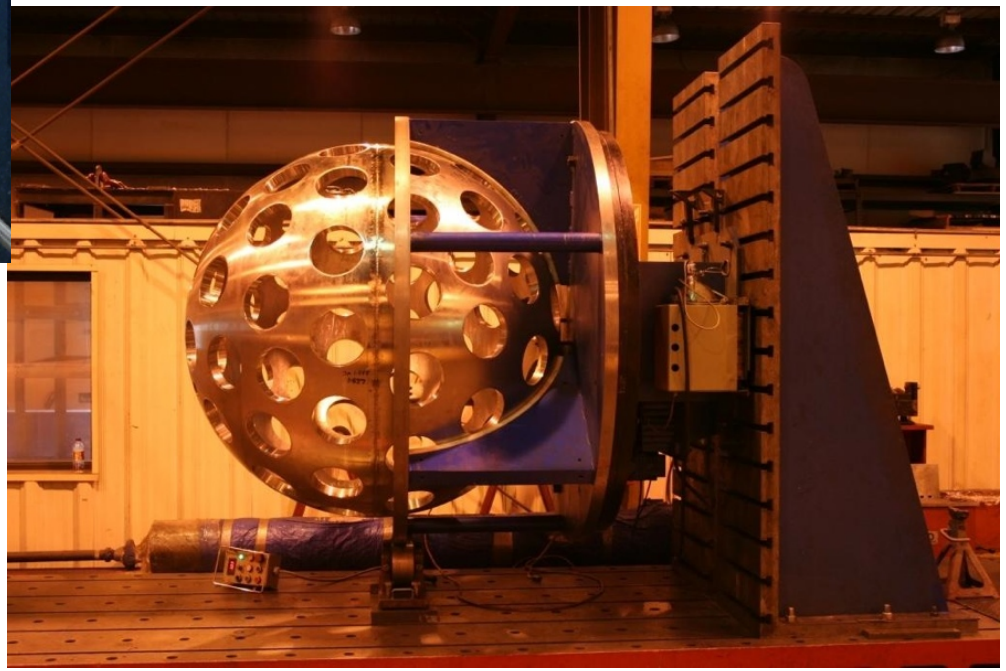
- Noble Liquids: DEAP-I, MiniCLEAN, & DEAP-3600
  - Single Phase Liquid Argon uses pulse shape discrimination.
  - Prototype DEAP-I operational in SNOLAB now, relocated to 'J' Drift. Successful demonstration of PSD and test bench for DEAP/CLEAN design/operations and background assessment.
  - Construction for DEAP-3600 and MiniCLEAN underway. Full DEAP-3600 capital funding granted
  - Will measure Spin Independent cross-section, reach anticipated 10^{-46} cm^2
- Superheated Liquid / Bubble chamber: PICASSO, COUPP
  - Superheated droplet detectors and bubble chambers. Insensitive to MIPS radioactive background at operating temperature, threshold devices
  - PICASSO currently operational, relocated to Ladder Labs, demonstration of alpha rejection and test bench for scale-up of detector volumes.
  - COUPP-4kg currently operational in 'J' Drift, 60kg Spring next year.
  - Will measure Spin Dependent cross-section primarily, COUPP has SI sensitivity
- Solid State: SuperCDMS
  - State of the art Ge crystals with ionisation and phonon readout.
  - Currently operational in Soudan. Next phase will benefit from SNOLAB depth to reach desired sensitivity. Test facility in Ladder Labs under development.
  - Mostly sensitive to Spin Independent cross-section.

Cube Hall - DEAP/miniCLEAN

MiniCLEAN / DEAP-3600 Construction

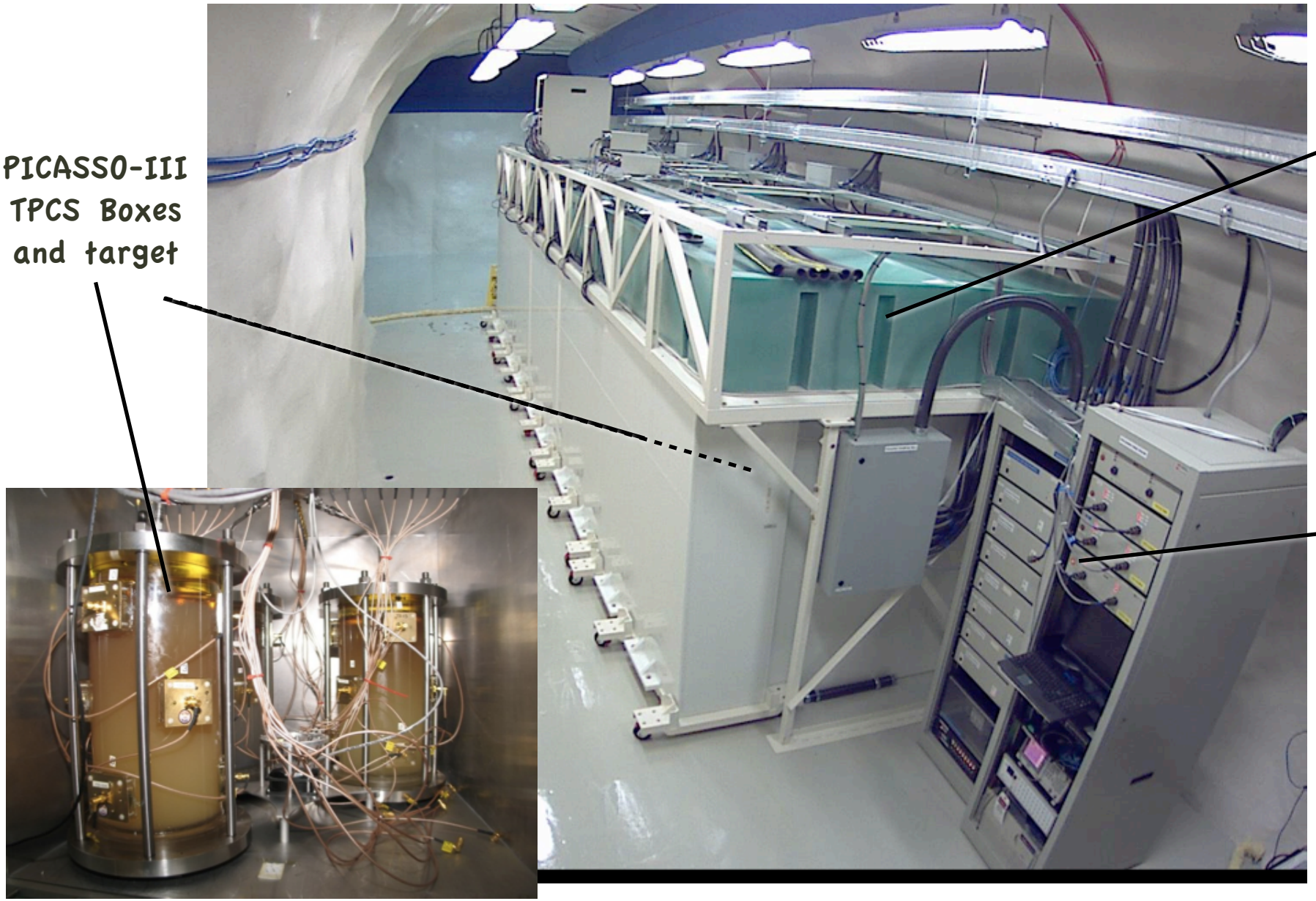


DEAP-3600 20" test-vessel machining at Alberta: bonding test. Main vessel panels procured, to be bonded and formed at RPT, CO

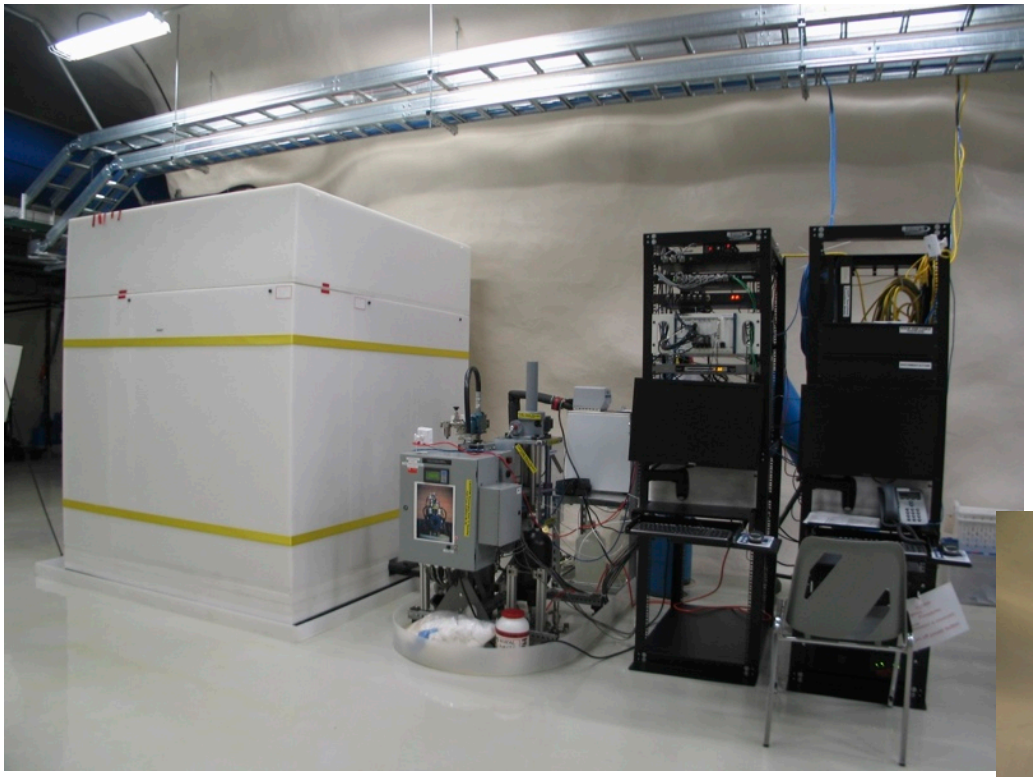


MiniCLEAN inner vessel final machining; PMT cassettes under construction

Ladder Labs - PICASSO



'J'-Drift: R&D + rapid deployment

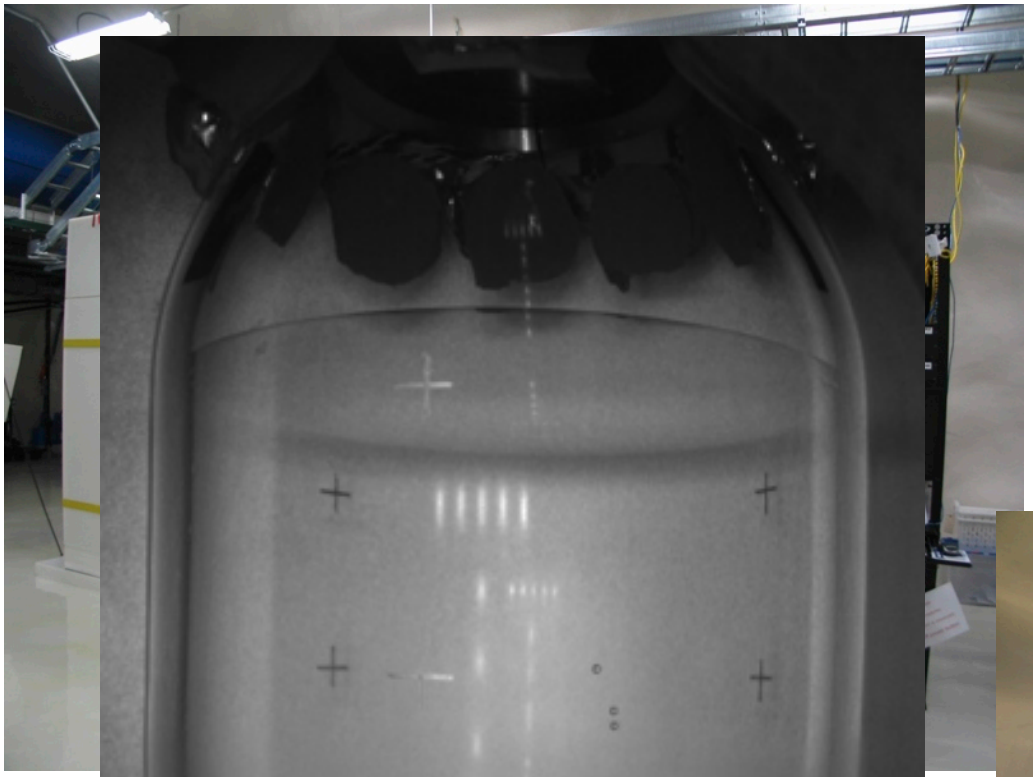


COUPP-4 bubble chamber, showing water tank shielding stack, pressure carts, DAQ racks

DEAP-I operational again, background and discrimination tests underway
COUPP-4 deployed during summer 2010 from Fermilab - background limited

DEAP-I in the 'J'-Drift, showing water cube shielding and purifier stack

'J'-Drift: R&D + rapid deployment



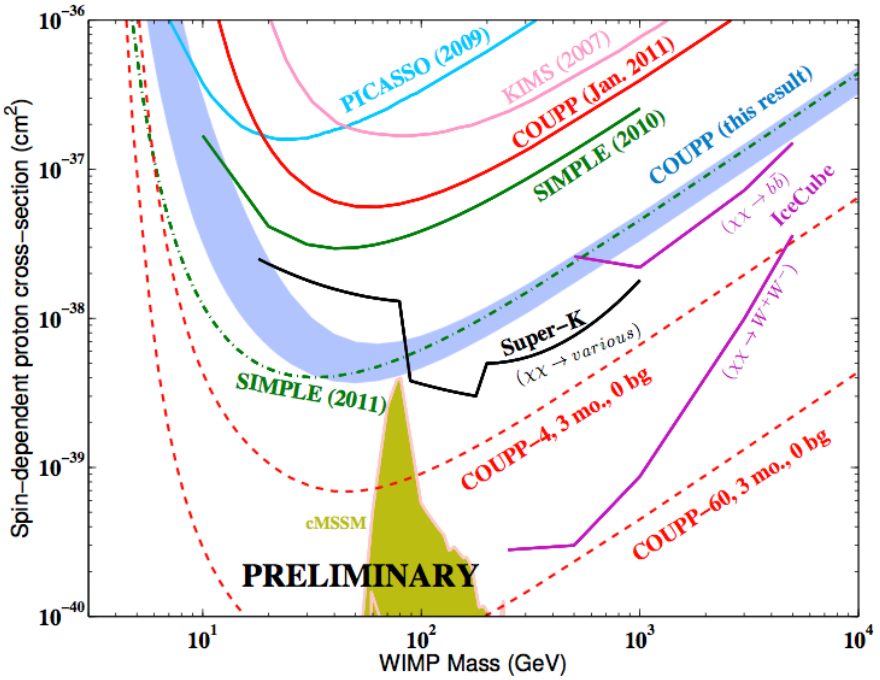
COUPP-4 bubble chamber, showing water tank shielding stack, pressure carts, DAQ racks

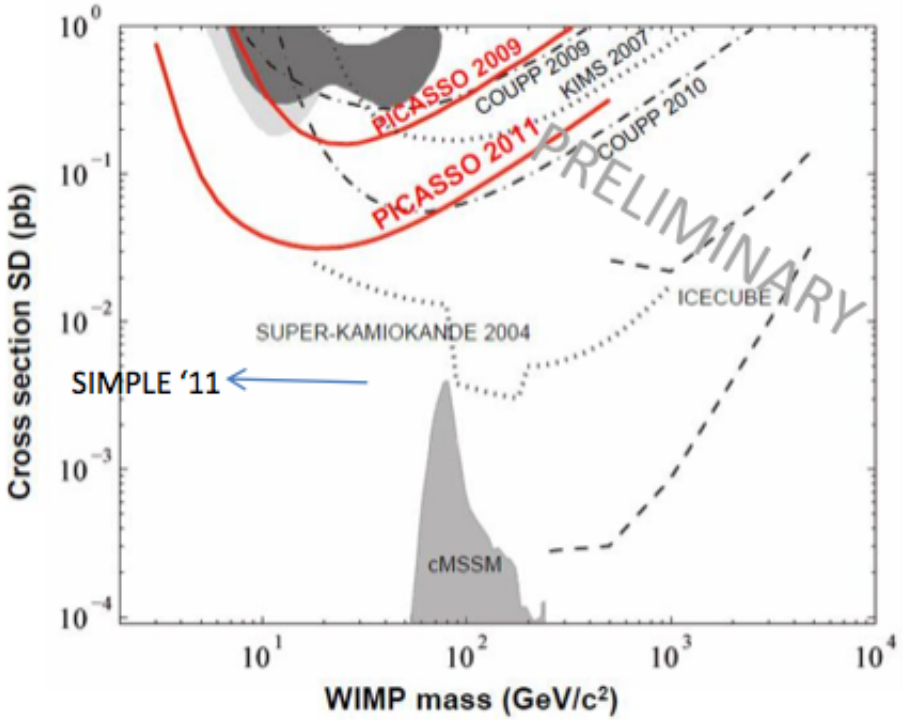
DEAP-
discri
COUPP
Fermil

DEAP-I in the 'J'-Drift, showing water cube shielding and purifier stack

Recent Results

- Both PICASSO and COUPP presented new results at TAUP 2011 (Munich)
- World-leading spin-dependent (on the proton) limits set
- New result from SIMPLE: reanalysis of existing data





SNOLAB Programme

Experiment	Solar nu	0nuBB	Dark Matter	SuperNovae	Geo nu	Other	Space allocated	Status
SNO+	√	√		√	√		SNO Cavern	Underway
PICASSO-III			√				Ladders Labs	Underway
DEAP-1			√				J'-Drift	Underway
DEAP-3600			√				Cube Hall	Underway
MiniCLEAN			√				Cube Hall	Underway
HALO				√			Halo Stub	Underway
PUPS						Seismicity	Various	Completed
SuperCDMS			√				Ladder Labs	Request
EXO-gas		√					Ladder Labs	Request
COUPP			√				Ladder Labs	Underway
DarkSide			√				Ladder Labs	Request
COBRA		√					Ladder Labs	Request

Current	DEAP-I, COUPP-4, PICASSO-III (Dark Matter)	EXO-Gas (Neutrino)
2011+	DEAP-3600, MiniCLEAN, COUPP-60 (Dark Matter)	SNO+, HALO, (Neutrino)
2012+	SuperCDMS (Dark Matter)	Exo-Gas (Neutrino)